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Investigate the effect of waste material in concrete using GGBS/Metakaolin/Silica Fume, Natural fiber and foundry Sand

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Abstract: This study has been undertaken to investigate the effects of waste materials in concrete using GGBS/ Metakaolin/Silica Fume with varying proportion. The combination of supplementary material like replacing 70% GGBS, 50%,60%, 70% metakaolin. All the material properties were found out as per the is code before using it. The M40 grade concrete having W/c ratio of 0.37 is adopted. In this work , 72 cubes were casted given the curing of 7 days , 28 days, and 90 days
The compressive strength test and slump cone test were performed. From this experimental investigation, it has been found out that the maximum strength is obtained by replacing 70% GGBS among all the proportion used. And sisal fiber has increased the strength of GGBS replaced concrete by 12.01%,11.23% and 9.25% at 7, 28 and 90 days.

Index Terms **– GGBS, Silica Fume, Metakaolin, Foundry Sand, Sisal Fiber, Compressive Strength**

1.INTRODUCTION

Concrete is a construction material composed of cement as well as other cementitious materials such as GGBS and metakaolin, silica fume, aggregate (generally a coarse aggregate such a gravel, limestone, or granite, plus a fine aggregate such as crush sand, foundry sand), water and chemical admixture concrete shows several desirable properties like high compressive strength, stiffness and durability. The use of supplementary cementitious material like GGBS, Silica Fume, Metakaolin helps to reduce issues like environmental, technical and financial caused by cement production.

The usage of such construction materials in concrete helps in reducing the disposal problem of waste materials. Waste Foundry sand is one on the industrial waste .In India the metallic casting organizations produces round 10 million MT of numerous grades of casting as of year 2015. Casting includes steel, aluminum alloy, ferrous, etc. India ranks 3rd at metal casting producer in the world as per data of 49th Census of world casting Production. Due to shrinkage and some other reasons , there are a generation of cracks in concrete, to reduce the cracks and enhance the mechanical properties of concrete. Fiber is being used nowadays as natural fiber is easily available and cheap as waste material.

2. LITERATURE REIVEW

2.1 T.V. Reshma et al. (2021)

Has investigated the mechanical and fresh properties of concrete specimen with partially replacing cement and sand with fly ash and foundry sand. WFS in different proportion is used for M40 grade. The compressive strength in found to be increased by 8.32% with 30% replacement by WFS.

2.2 Sabrish et al. (2018):

Analysed the effect of sisal fiber reinforced concrete. Sisal fiber is reinforced with varying percentage (0%, 0.5%,1%,1.5% and 3%.) by weight of cementitious material. 1% reinforcement of sisal fiber has given the best result among all the percentage. And further increases in sisal fiber content leads to the porous structure by agglomeration.

2.3 babar Ali et al. (2020):

Has studied the effect of silica fume on concrete. 10% replacement of cement has improved the compressive strength of concrete specimen.the free CH reacts with the silica fume , increases the strength of cement paste. Silica fume helps in reducing the voids in concrete.

2.4 Gannavarapu Naga et(2022):

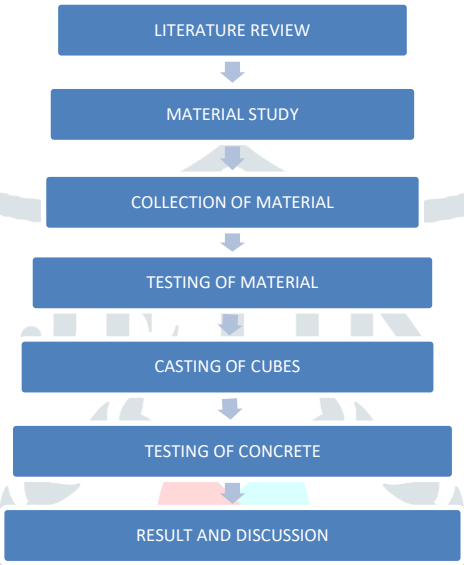
Has investigated the mechanical properties of metakaolin based concrete. The partial replacement of metakaolin with 5%, 10%, 15% and 20% by mass of cement is researched in phase 1 and in phase 2 the combination of natural and artificial fiber is added to it. The optimum compressive strength found to be increased by 13.40% at 10% replacement of cement.

2.5 Santosh et al.(2.15):

Examined the effect of adding GGBS in Portland cement concrete. The research paper studied the characteristics of M20 and M40 grade concrete. The percentages of GGBS used were 30%,40%, and 50%. The tests such as compression, tension, split tensile, and flexural strength test were carried out and it was found compressive and split tensile strength has increased upto 40% replacement by GGBS.

3. METHODOLOGY

RESEARCH METHODOLOGY



3.1Materials

3.1.1 Cement: Cement is an binder which is used to bind fine aggregates and coarse aggregates to make concrete and left to dry, it is flexible material used in construction . In this project OPC 53 grade cement is going to be used. According to IS 4031:1988, the cement was tested and it's confirmed to IS 12269:2004.

Physical characteristics of cement

Sr. No.	Properties	Value
1	Specific gravity	3.1
2	Mean grain size (µm)	22.5
3	Specific area cm2/gm	3250
4	Colour	Ivory to Cream

Chemical characteristics of cement

Properties	Composition%
SiO2	20.25
Al2O3	5.04
Fe2O3	3.16
`CaO	63.61
MgO	4.56
K2O	0.51
LOI	3.12

3.1.1 Fine Aggregate: Crush sand locally available in the market was used in the investigation. The aggregate was tested for its physical requirements such as gradation, fineness modulus, specific gravity and bulk density in accordance with IS: 2386- 1963.

Physical characteristics of crush sand

Sr. No.	Properties	Value
1	Specific gravity	2.885
2	Water absorption	2.45
3	Zone	I
4	Fineness Modulus	2.17

3.1.2 Coarse Aggregate : The coarse aggregate contributing most to strength parameter. It is strongest component of concrete. It reduces motion of moisture and drying shrinkage. The 20mm and 10mm aggregate are used in proportion of 60:40.

Physical characteristics of coarse aggregate

Sr. No.	Properties	Value	
		20mm	10mm
1	Specific gravity	2.91	2.95
2	Fineness Modulus	6.28	7.52
3	Water absorption (%)	1.08%	0.86%
4	Compacted bulk density	1.686	1.632
5	Loose bulk density	1.606	1.57

3.1.3 Metakaolin: It is manufactured product rather than a by-product and is formed when china clay, the mineral kaolin, is heated to a temperature between 700 to 900 0C.

OPC+Water = Calcium silicate + Calcium Hydroxide
(cementitious) (non-cementitious)

Calcium Hydroxide + Metakaolin = Calcium Aluminate + Calcium Alumino Silicate
(cementitious) (cementitious)

Physical characteristics of Metakaolin

Sr. No.	Properties	Value
1	Specific gravity	2.67
2	Mean grain size (µm)	2.54
3	Specific area cm2/gm	150000-180000
4	Colour	White
5	Consistency	86%

Chemical characteristics of Metakaolin

Properties	Composition%
SiO2	60-65
Al2O3	30-34
Fe2O3	1.00
CaO	0.2-0.8
MgO	0.2-0.8
K2O	0.5-1.2
LOI	<1.4

3.1.4: Silica Fume: Silica fume is very active pozzolona material, and it reacts rapidly with free calcium silicate hydrates. It is also acts as binder material

Physical characteristics of Silica fume

Sr. No.	Properties	Value
1	Specific gravity	2.57
2	Mean grain size (µm)	0.15
3	Specific area cm2/gm	1500000-300000
4	Colour	White

Chemical characteristics of Silica Fume

Properties	Composition%
SiO2	85
Al2O3	-
Fe2O3	-
CaO	0.2-0.8
MgO	0.2-0.8
K2O	-
LOI	<6.0

3.1.5 Foundry Sand: It contains high Percentage it is used. Foundry Sand. Foundry sand is good for thermal conductivity. It reduces the workability of material

Physical characteristics of Foundry Sand

Sr. No.	Properties	Value
1	Specific gravity	2.67
2	Water absorption (%)	0.3
3	Fineness modulus	2.02

3.1.6 sisal fiber: It is a natural fiber. Sisal fiber is extracted from the plant named as agave. It is available in the length between 190-650 mm.

Physical characteristics of Sisal fiber

Sr. No.	Properties	Value
1	Diameter of fiber	0.15-0.65
2	% in elongation	15.9
3	Length of fibre (mm)	190-650

3.1.7 GGBS:
GGBS is economical in use and provides good resistance to concrete in aggressive environments and enhanced the mechanical parameter and durability of concrete. It is obtained by using molted iron slag from a blast kiln in water to supply a glassy grainy product.

Physical characteristics of GGBS

Sr. No.	Properties	Value
1	Specific gravity	2.87
2	Fineness	4250
3	Colour	Off-white

Chemical characteristics of GGBS

Properties	Composition%
SiO2	39.18
Al2O3	10.18
Fe2O3	2.02
CaO	32.82
MgO	8.52
K2O	0.30
LOI	1.0

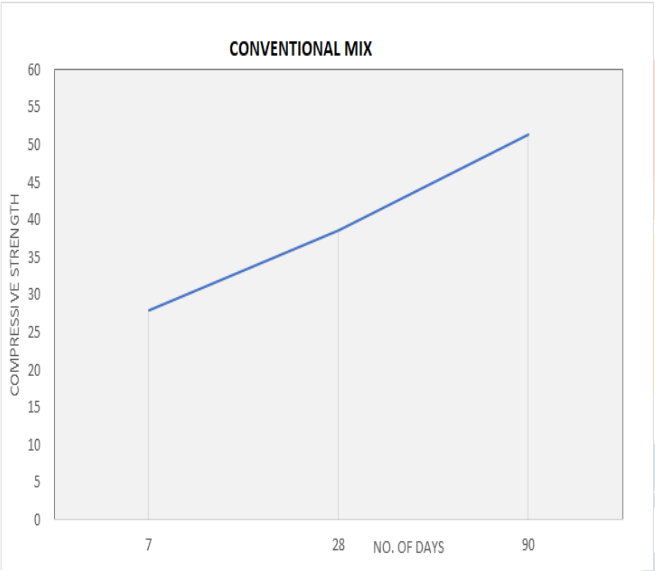
3.2 Mix Proportion

For this research, authors used M40 grade concrete as per Indian standard IS:10262-2019.Totally six mixes Conventional mix , 70% Silica fume and 30% metakaolin of whole 80% replacing cement, 70% metakaolin only, 50% metakaolin only, 60 metakaolin only, 70% GGBS with Sisal fiber , 70% GGBS without Sisal fiber are casted. Replacing 30% fine aggregate with foundry sand in all combination with 1% sisal fiber. An investigatin of fresh and mechanical properties of M40 grade is being done. 63 cubes were casted. And curing of 7 days. 28 days and 90 days is done.

4. RESULTS AND DISCUSSION

After casting of concrete cubes, they are test in our laboratory and the test results are tabulated as below: -

Sr.No.	strength at respective days (N/mm2) Design proportion	7 days	28 days	90 days
1	Conventional concrete	28.01	38.59	51.36
2	Replacing 80% of cement with combine proportion of 70:30 silica fume and metakaolin	0.98	4.86	4.66
3	70% metakaolin only	7.04	12.94	15.62
4	50% metakaolin only	13.70	22.76	25.85
5	60% metakaolin only	8.02	14.86	15.47
6	70% GGBS only	23.12	33.86	34.74
7	70% GGBS without sisal fiber	20.64	30.44	31.77



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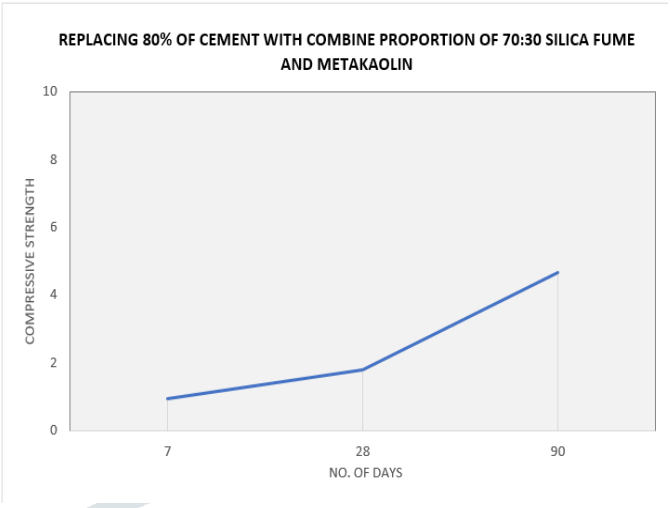

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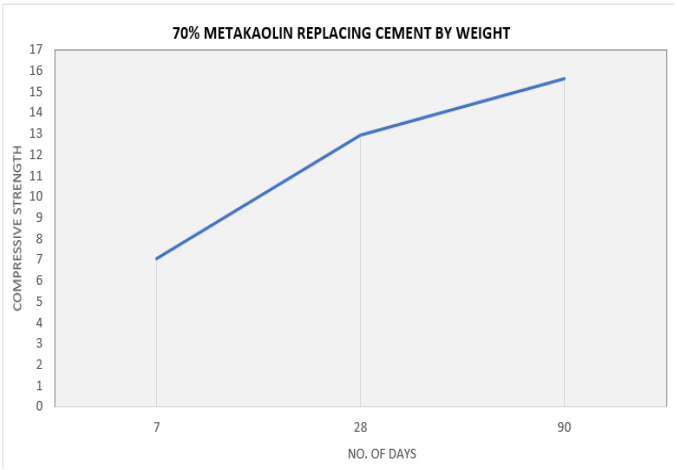

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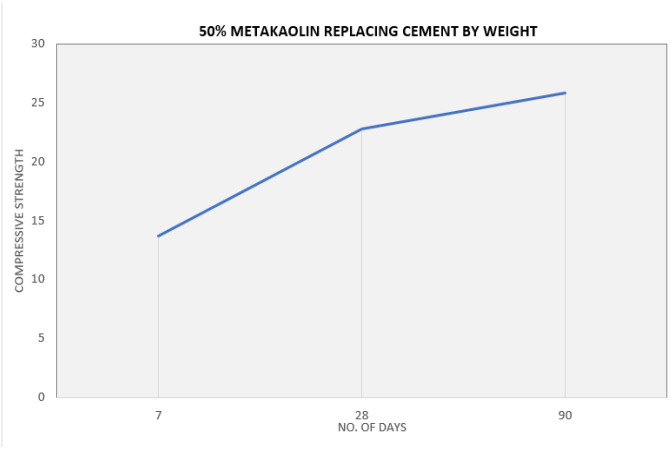

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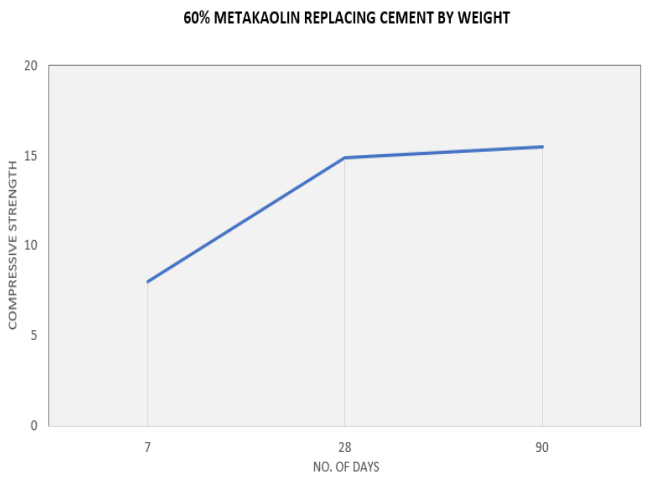

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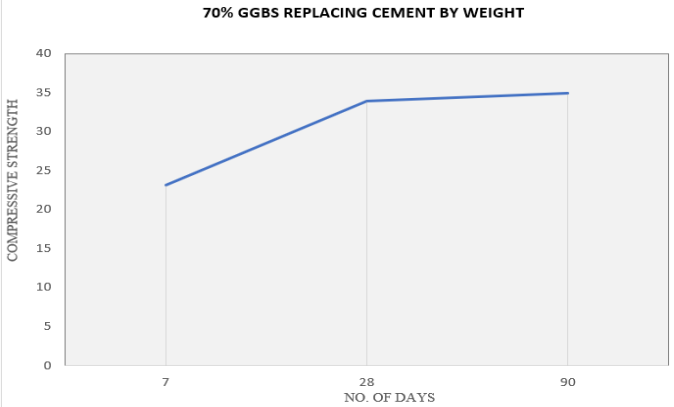

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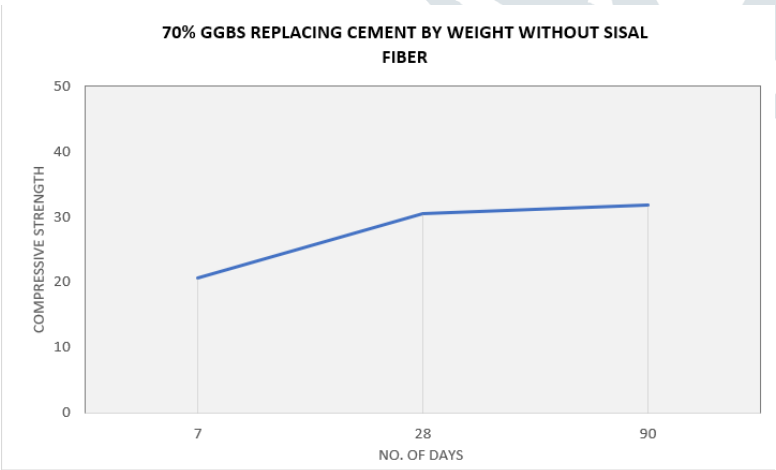

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5. CONCLUSION

1. From all the proportions, the mix design of replacing cement with 70% GGBS and 1% sisal fiber 30% foundry sand has given the maximum strength compared to other proportions casted.
2. The addition of sisal fiber has increased the stiffness of concrete.
3. Sisal fiber helps in bridging the cracks and thus helps in increase in compressive strength of the concrete.
4. Foundry sand has helped to control the workability of concrete.
5. The sisal fiber has increased the compressive strength of concrete by 9-12%

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